

# Gabor filters and phase portraits for the detection of architectural distortion in mammograms

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**Abstract** Architectural distortion is a subtle abnormality in mammograms, and a source of overlooking errors by radiologists. Computer-aided diagnosis (CAD) techniques can improve the performance of radiologists in detecting masses and calcifications; however, most CAD systems have not been designed to detect architectural distortion. We present a new method to detect and localise architectural distortion by analysing the oriented texture in mammograms. A bank of Gabor filters is used to obtain the orientation field of the given mammogram. The curvilinear structures (CLS) of interest (spicules and fibrous tissue) are separated from confounding structures (pectoral muscle edge, parenchymal tissue edges, breast boundary, and noise). The selected core CLS pixels and the orientation field are filtered and downsampled, to reduce noise and also to reduce the computational effort required by the subsequent methods. The downsampled orientation field is analysed to produce three phase portrait maps: node, saddle, and spiral. The node map is further analysed in order to detect the sites of architectural distortion. The method was tested with 19 mammograms containing architectural distortion. In a preliminary experiment, a sensitivity of 84% was obtained at 7.8 false positives per image.

**Keywords** Architectural distortion · Phase portraits · Oriented texture · Gabor filters · Mammography · Breast cancer · Computer-aided diagnosis

## 1 Introduction

Breast cancer is one of the most important malignancies in women: statistics from the National Cancer Institute of Canada show that the lifetime probability of a woman developing breast cancer is one in 8.9, with a lifetime probability of one in 26.8 of dying due to the disease [30]. The importance of early detection of breast cancer is evident: whereas localised cancer is associated with a five-year survival rate of 97.5%, disseminated cancer leads to a 5-year survival rate of only 20.4% [19].

Mammography is the best available tool for early detection of breast cancer. However, the sensitivity of screening mammography is influenced by image quality and the radiologist's level of expertise. Bird et al. [7] estimated the sensitivity of screening mammography to be between 85 and 90%. They also observed that misinterpretation of breast cancer signs accounts for 52% of the errors, and overlooking signs is responsible for 43% of the missed lesions. The extent of errors due to overlooking of lesions reinforces the need for computer-aided diagnosis (CAD) tools in mammography.

The breast is seen in a mammogram as a directionally oriented, textured image due to its fibroglandular tissue, ligaments, blood vessels, and ducts [17]. Architectural distortion is a subtle mammographic abnormality, defined in BI-RADS™ [1] as follows: “The normal architecture (of the breast) is distorted with no

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